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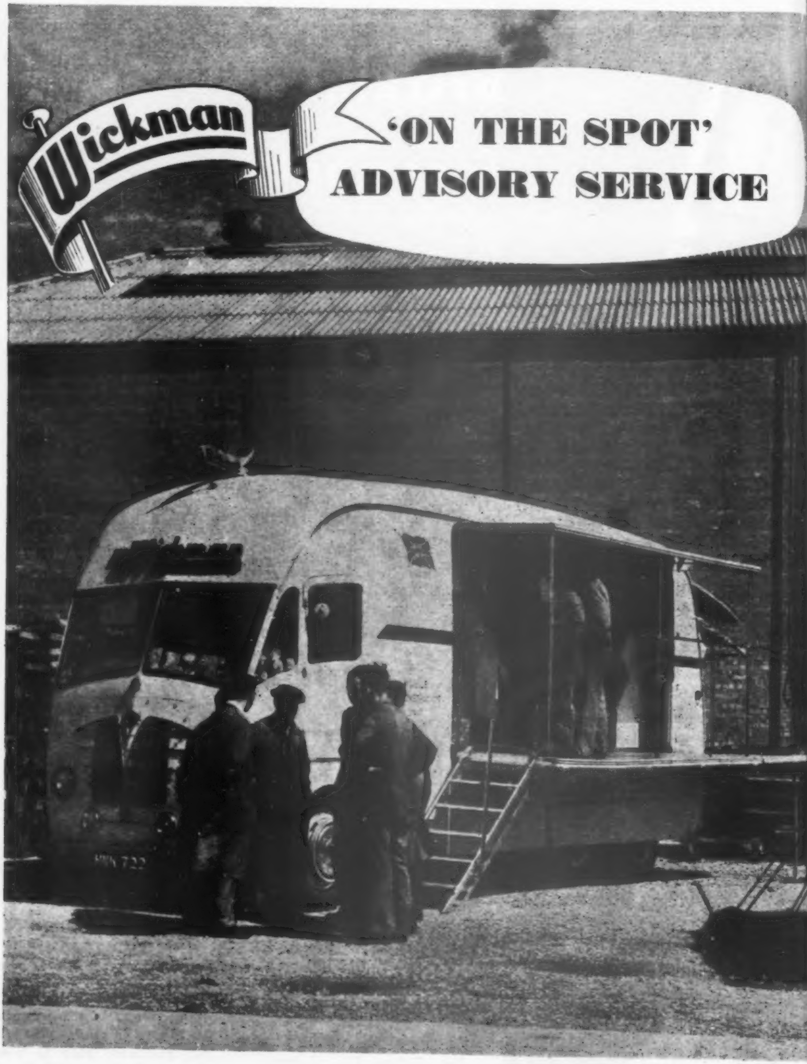
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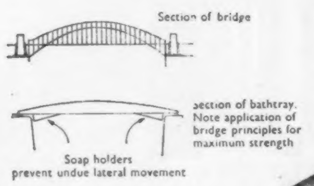
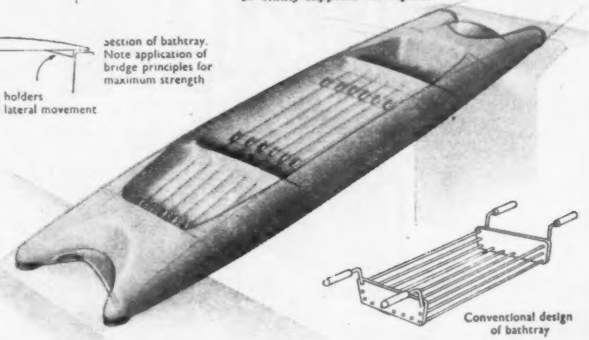
Designer's Diary No. 4

In this series the B.I.P. Product Design Unit seeks to illustrate how technical requirements can be met to produce pleasing, readily mouldable articles in plastics. Reprints of these announcements will be gladly supplied on request.





The Product. Of the few attempts to mould a bathtray, all have so far followed the general characteristics of their wooden and metal predecessors. Two basic faults are the tendencies of such trays to slide about and fall into the bath ; and their seat-like structure which, whilst inviting such use, does not make for great strength when reproduced in plastics. This new conception of a bathtray primarily aims to overcome these faults.

The Design. In contrast to traditional design, note first the strong *bridge-like* structure of this bathtray. For additional strength vertical divisions are incorporated between compartments and on what would otherwise be flat surfaces are moulded internal ribs and drain-channels. To locate and anchor the tray, two novel features are incorporated. The soap compartments provide a location to prevent undue lateral movement, whilst four small rubber suction pads on the underside prevent the bathtray slipping. An unobtrusive lifting handle at each end provides a fingerhold for lifting against suction. This bathtray represents a simple compression job for straightforward up-and-down moulding.

The Material. Beetle urea moulding powder is recommended because it provides a wide colour range complementary to contemporary bathroom colour schemes. Although there will be some expansion and contraction due to changes of temperature and humidity, dimensional considerations are not critical in this application. Urea material is, therefore, the most economical to use for the job.

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Calcutta	J. Warren-Boulton, c/o Machine Tools (India) Ltd., Stephen House, Dalhousie Square, Calcutta.

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Contents

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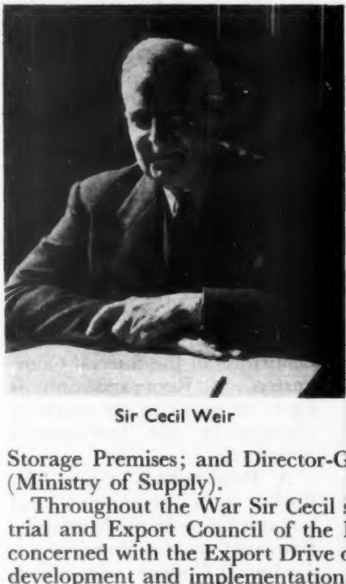
THE PRINCIPAL OFFICERS, 1952/53

The President

SIR CECIL M. WEIR, K.B.E., M.C., D.L.

SIR CECIL WEIR, who assumes office as President of the Institution on 1st July, 1952, is known internationally as a public servant and industrialist of the widest experience.

After completing his education in Scotland, Switzerland and Germany, he served throughout the First World War in Gallipoli, where he was wounded in 1915, and in France.



Sir Cecil Weir

During his business life in Glasgow, as partner in the old-established firm of Schrader, Mitchell and Weir, Sir Cecil was a Deputy Chairman of the Scottish Development Council, President of the Glasgow Chamber of Commerce, and Chairman of the Administrative Committee of the Empire Exhibition (Scotland) 1938.

From 1938 to 1940 he was Civil Defence Commissioner for the Western District of Scotland. During the later stages of World War II, he was consecutively an Executive member of the Export Council of the Board of Trade; Controller-General of Factory and Storage Premises; and Director-General of Equipment and Stores (Ministry of Supply).

Throughout the War Sir Cecil served as a member of the Industrial and Export Council of the Board of Trade, and was closely concerned with the Export Drive of 1940 and subsequently with the development and implementation of the wartime Concentration of Industry. He was also Chairman of the Committee which investigated the operation of the Mersey Docks in the early part of the War, and of several other Government Committees set up at that time to deal with Design, Management, Exhibitions and Fairs.

After the liberation of Paris in 1944, Sir Cecil was appointed the British Chairman of the Anglo-American Mission (the Weir-Green Mission) which carried out an investigation of the state and potentialities of French industry, transport and power at that time.

In 1946 he went to Germany as President of the Economic Sub-Commission in the Control Commission for Germany, where he remained for more than three years until the Federal German Government took office in 1949. Shortly after returning to the United Kingdom, in the same year, Sir Cecil was appointed Chairman and Chief Executive of the Dollar Exports Board, which post he relinquished at the end of June, 1951, when he returned to business activities after twelve years of continuous public service.

In addition to his partnership in the family business, Sir Cecil is Chairman of the British Tabulating Machine Co. Ltd., and a Director of British Enka, Ltd., and Pyrene, Ltd. He resigned his other directorships on proceeding to Germany in 1946.

The further progress and development of the Institution can be confidently anticipated under the guidance and counsel of a President of such distinction and authority.

The Chairman of Council

MR. HAROLD BURKE, M.I.Mech.E., M.I.Prod.E., M.I.I.A.

MR. BURKE, Director and General Manager of Concentric Manufacturing Company Limited, and Director of a subsidiary Company, Metaducts, Limited, is known throughout the Institution for his valuable contributions to its activities and progress. His recent work as Chairman of the Special Committee on Reorganisation is likely to result in far-reaching changes in the Institution's structure.

Mr. Harold Burke

(Photo by courtesy of L. E. Broome)

A Birmingham man, Mr. Burke is a prominent and popular figure in the Midlands. Educated at the Birmingham Technical College, with which he has been associated for over 30 years as Student, Lecturer and a member of various Committees, he served his apprenticeship with Vickers, Ltd., after which he spent several years in the shops with T. A. Savery & Co., Ltd. In

1929 he was appointed Production Manager at Premier Electric Heaters, Ltd., resigning in 1936 to become General Works Manager for Bendix, Ltd.

In 1945, Mr. Burke became Works Director and later Deputy Managing Director of Air Industrial Developments, Ltd., and two years later joined Elfson, Ltd., as Managing Director. When the Engineering Division of this Company was purchased by Concentric Manufacturing Co., Ltd., Mr. Burke accepted his present appointment.

During the Second World War Mr. Burke served in the 38th Batt., Warwickshire Regiment (Home Guard) as a Company Commander with the rank of Major.

Mr. Burke was elected to membership of the Institution in 1932 and at once began to play an active part in the affairs of the Birmingham Section. For four years he was the extremely energetic Hon. Secretary and was subsequently elected Section President, an office he filled with distinction. He is currently Vice-President of the Section, and has been a Member of Council since 1948.

In addition to his professional interests and his work for the Institution, Mr. Burke is active in public life. He is a member of the Board of Governors of Boldmere Secondary School, and of the Advisory Council, Birmingham College of Technology. He is also deeply interested in social work in Sutton Coldfield in connection with help for the aged, hospitals, and the Infantile Paralysis Fellowship.

Among his hobbies are music and amateur operatics and dramatics, and he is Chairman of the Emily Broughton Players.

INSTITUTION NOTES

July, 1952

The Queen Honours The President

The Institution offers warm congratulations to its new President, Sir Cecil Weir, on his inclusion in the recent Birthday Honours. Sir Cecil becomes a Knight Commander of the Most Distinguished Order of St. Michael and St. George, in recognition of his services as Chairman of the Dollar Exports Board.

Council Elections 1952/53

As a result of the Ballot, the following members have been elected to serve on Council for the year 1952-53:

Members: Mr. A. J. Aiers.
Mr. B. H. Dyson.
Mr. P. G. Garside.
Mr. B. G. L. Jackman.
Mr. H. J. Swift.

Associate Member: Mr. J. E. Burnett.

The next Council Meeting will be held at 36, Portman Square, London, W.1, on Thursday, 24th July, 1952.

Course in Electronics

The Birmingham Section of the Institution has recently been concerned in initiating arrangements for Extra Mural Courses on subjects of interest to Production Engineers, and one of the subjects suggested by the Section Committee was " Electronics."

The Departments of Extra-Mural Studies and of Electrical Engineering at the University of Birmingham have adopted this suggestion, and a Summer School on the Fundamental Characteristics of Electronic Apparatus has been arranged to take place at the University from 14-19th July, 1952.

The lectures are intended to show both the designer and user of electronic apparatus how far engineering problems are circumscribed by physical laws. Various electronic devices have been grouped into a series of topics, and as far as possible each topic will be opened with a general theoretical lecture, followed by contributions on particular practical applications.

All enquiries regarding the Course should be made to The Director of Extra-Mural Studies, The University, Edmund Street, Birmingham, 3.

Course on Work Study Organisation and Development

The 1952 Residential Summer Course arranged by the Department of Engineering Production, Birmingham University, under the direction of Professor T. U. Matthew, will take as its subject "Work Study Organisation and Development."

In addition to lectures, case study work and discussions, consideration will be given to the full implications of the results of the National Survey on Time Study Practice. It is also intended to present for the first time a new organisational method which has been developed in the Department for the more systematic use of scientific and technical data in product engineering and process study.

The Course which will be held from Monday, the 21st July, to Friday, the 1st August, is intended for Production Managers, Industrial Engineers and Executives concerned with the application and development of works study principles in industry.

NEWS OF MEMBERS

Mr. F. R. Ball, Associate Member, has taken the position of Machine Shop Manager with the Anti-Attrition Metal Co. Ltd., Maidenhead.

Mr. P. V. Brown, Associate Member, is now employed as an Engineer III with the Directorate of Aircraft Production Development, London.

Mr. H. F. C. Digby, Associate Member, is Assistant Works Manager with the Forgrove Machinery Co. Ltd., Leeds.

Mr. A. A. Francis, Member, of A. E. C. Ltd., Southall, has been appointed Production Engineer with that Company.

Mr. R. Glegg, Associate Member, has been promoted to the post of Chief Mechanical Engineer for the Port of Calcutta.

Mr. J. A. Holmes, Member, is now Manager of Amalgamated Products Ltd., Auckland, N.Z.

Mr. D. S. Kanwar, Associate Member, is now Officer-in-Charge (Panel Shops) with the Indian Standard Wagon Co. Ltd., Burnpur, West Bengal, India.

Mr. C. S. Kent, Associate Member, has joined Girling Ltd., Newport, as Manager of the Suspension Damper Factory.

Mr. W. S. Langford, Member, has joined Messrs. F. Issels & Son, Bulawayo, as General Manager.

Major J. H. Partridge, R.E.(Retd.), Member, Master of the Mint, India Government Mint, Calcutta, has also been appointed Master of the India Government Mint, Alipore (Calcutta) of which he has been Officer-in-Charge Construction for the past four years.

Mr. W. Pilkington, Associate Member, has been appointed Chief Jig and Tool Draughtsman with the Bristol Aeroplane Co. Ltd., Sunderland.

Mr. L. H. Sewell, Associate Member, of A.E.C. Ltd., has been promoted Works Manager of that Company.

Mr. H. L. Sharp, Associate Member, has been appointed General Manager to the New Mendip Engineering Company, Melksham.

Mr. I. S. Varman, Associate Member, is now Assistant Mechanical Engineer with the Calcutta Electrical Manufacturing Co. Ltd., Calcutta.

Mr. B. Booth, Graduate, has left Metropolitan-Vickers Electrical Co. Ltd., Manchester, and is now Executive Engineer with the Sudan Mercantile Company (Engineers) Ltd., Khartoum.

Mr. E. J. Bradley, Graduate, has been appointed Manager of the Constructional Department of Round Oak Steelworks Ltd., Brierley Hill, Staffs.

Mr. E. Fedder, Graduate, has taken the position of Works Manager with Emco Brass Manufacturing Co. Ltd., Croydon.

Mr. R. A. Hinkley, Graduate, has been appointed Materials Handling and Plant Layout Engineer with Humber Ltd., Coventry.

Mr. K. D. C. Smith, Graduate, is now a Technical Engineer in the Design and Specifications Division of British Insulated Callender Cables Ltd.

Mr. P. H. C. Waddington, Graduate, has been transferred to the Stafford Works of the English Electric Co., and has been appointed Standards Engineer.

Visitors from Abroad

Mr. H. Gibson, Member, Chairman of the Calcutta Section of the Institution, is visiting the United Kingdom this summer.

Mr. R. W. Deutsher, Associate Member, who is a member of the Australian Sub-Council and Assistant Hon. Secretary of Melbourne Section, is now on an extended tour of England, the Continent and the U.S.A., in order to study the latest production techniques and practices.

Obituary

The Institution records with deepest regret the death, in May, 1952, of Mr. Harry Hallam, first Section President from 1934 to 1935 of the Leicester Section of the Institution of Production Engineers.

Mr. Hallam was a Director and Works Manager of the British United Shoe Machinery Co. Ltd., with whom he had been associated for 54 years, having joined the firm as an apprentice in 1899.

He was a well-known personality in local engineering circles, having been for 25 years Chairman of the Foremen's Mutual Benefit Society in connection with The Leicester and District Engineering and Allied Employers' Federation.

British Standards The following Standards have recently been issued, and may be obtained, post free, at the prices stated from the British Standards Institution, 24-28, Victoria Street, Westminster, London, S.W.1:

B.S. 919: 1952 Screw Gauge Limits and Tolerances. (5/-)
B.S. 1817: 1952 Tins for Honey. (2/-)
B.S. 1857: 1952 Pipe Cutters. (3/6)

HAZLETON MEMORIAL LIBRARY

It would be helpful if, in addition to the title, the author's name and the classification number could be quoted when borrowing books.

REVIEW

517.2. CALCULUS.

"Calculus" by Lyman M. Kells. (2nd Ed.) *Lond., Allen & Unwin*, 1951. 508 *pages*. *Frontispiece*. 28/-.

In common with other American text books of a scientific type, "Calculus" is well planned and introduces the student gradually to the more intricate sections of the subject. The book is essentially a student's text book, and starting from basic concepts, it covers the subject up to partial differentiation, multiple integrals, infinite series, and ordinary differential equations. The numerous examples are well matched to the subject matter of the various sections and enable the student to gain confidence gradually.

There are several cases where the author appears to assume previous knowledge by the reader and the explanations may thus appear rather confusing to the beginner. This applies in the case of harmonic motion and vectors. Although amply covered, these subjects could perhaps be dealt with in a manner more suitable for beginners. A further minor but important point could well be brought out, namely the symbolic nature of $\frac{\delta f}{\delta x}$. Although well-known to the advanced student, it would be well worth while stressing for the benefit of the beginner.

The above criticisms are generally only of a minor nature and the book can be recommended as an efficient text-book.

ABSTRACTS

159.9. PSYCHOLOGY

"Psychology and the Industrial Worker" by E. G. Chambers. *Cambridge, C.U.P.*, 1951. 190 *pages*.

The book, presenting the outlook of a Director of Research, is broader in treatment of its subject than would be expected from a research worker in a particular field. The treatise is basic rather than specific. It defines work as beneficial when undertaken as a purposive activity. It surveys the methods of psychologists and points broad direction for application of the science to serve industry in bringing about an understanding of the problems of attitude, well-being and satisfaction of the worker, which, if solved, could be a means of eliminating the biggest obstacle to successful industry.

The psychologist aims at maximum satisfaction through work, which includes efficiency in working, therefore increased industrial efficiency. Vocational guidance is a better approach towards fitting the man to the job than is vocational selection. Physical environment affects the efficiency of the worker, improvement pays a dividend. Psychological environment involves consideration of incentives, a matter discussed at length.

620.1. ENGINEERING MATERIALS.

"Engineering Materials Manual" by T. C. Dumond, *Ed. New York, Materials and Methods, Reinhold Pub. Corp.*, 1951. 386 *pages. Illustrated. Diagrams.* 36/–.

This volume is a collection of articles which have appeared during the last few years in the series of Material and Methods Manuals and published in America in "Materials and Methods".

It comprises 28 sections covering: Engineering Steels of all types, grades and alloys—Wrought Aluminium Alloys—Magnesium Alloys—Nickel and Nickel Alloys—Bronzes—Beryllium Copper—Bearing Metals—Cemented Carbides—Ceramics—Rubber—Plastics—Hard Facing Materials—Finishes—Electroplating—Colouring, Porcelain Enamels, and Adhesives.

Each section deals with development—physical and analytical properties—processing—selection and application—design considerations. There are many illustrations, tables and charts.

658. INDUSTRIAL ORGANISATION: MANAGEMENT.

"Industrial Administration and Management" by F. L. Meyenberg. *Lond., Pitman*, 1951. 387 *pages*. 35/–.

This textbook presents a broad survey of the role of Industrial Administration and Management, and the material is presented methodically by tracing the route of a customer's order through the various departments of an industrial concern.

The examination of departmental activity is arranged in five sections—Sales Promotion, Design, Production Planning and Control, Execution of Work Orders and Economic Control. Each section is comprehensive despite the limitations imposed by covering such a wide subject in one book. For example, the section dealing with the Execution of Works Orders covers the activities of the Purchasing Department; Receiving and Storage of Materials; Material and Human Factors in Production including Wages Payment, Incentives and Personnel Management; Industrial Legislation; Inspection; Standardisation and Miscellaneous Production Matters.

Though the last section of the book, Economic Control, is separated from the first four sections for ease of presentation, continuous stress is laid throughout the book on the importance of considering all activities within the works as within the sphere of economic control.

331.124. SUPERVISION: FOREMANSHIP.

"The Foreman: A Study of Supervision in British Industry" by National Institute of Industrial Psychology, *London*. Undertaken by the National Institute of Industrial Psychology, and sponsored by the Human Factors Panel of the Committee on Industrial Productivity. *Lond., Staples Press*, 1951. 158 *pages*.

This investigation was carried out by a research team and took the form of personal visits to factories, analyses of the questionnaires sent to numerous firms, and the studying of international literature on the subject. The report does not claim to be completely representative of British supervision but is offered as a means for promoting comments and suggestions likely to be relevant to the greater part of industry.

The points covered in the survey relate to the job of the Supervisor; selection; training; position with regard to the functional departments; union relationship; and status within the company.

Included in the appendices are: the list of firms visited, a copy of the questionnaire, which was circulated, and the tabulated summaries of data obtained.

OTHER ADDITIONS

614.8. PREVENTION OF ACCIDENTS: SAFETY MEASURES

U.S.A.—*Dept. of Labor—Bureau of Labor Standards.* **"Machine Tools and Their Hazards."** *Washington, U.S. Gov. Pr. Office,* 1951. 34 *pages. Illustrations.*

621.357. ELECTRO-DEPOSITION; ELECTRO-FORMING; ELECTRO-PLATING

Wernick, S. **"Electrolytic Polishing and Bright Plating of Metals."** (2nd Ed.) *Lond., Alvin Redman Ltd.,* 1951. 243 *pages. Illustrated. Diagrams.*

Whittaker, Alan. **"Electroplating and the Engineer."** *Manchester, Emmott & Co. Ltd.,* 1951. 87 *pages. Illustrated.* (*Mechanical World Monographs.*)

621.74. FOUNDRY WORK

Howard, E. D., *ed.* **"Modern Foundry Practice."** *Lond., Odhams Ltd.* [n.d.] 384 *pages. Illustrated. Diagrams.*

Carrington, E. **"Aluminium Alloy Castings, Their Founding and Finishing."** *Lond., Griffin,* 1946. 326 *pages. Illustrated. Diagrams.*

621.791. WELDING

Aluminium Company of America, *Pittsburgh, Pa.* **"Welding and Brazing Alcoa Aluminium."** *Pittsburgh, the Company,* 1948. 135 *pages. Illustrated. Diagrams.*

621.83. GEARS

Gleason Works, *Rochester, N.Y.* **"Spiral Bevel Gear System: Standardized Tooth Proportions for Generated Spiral Bevel Gears."** *Rochester, N.Y., the firm,* 1943. 113 *pages.*

Gleason Works, *Rochester, N.Y.* **"Straight Bevel Gear System: Standardized Tooth Proportions for Generated Straight Bevel Gears."** *Rochester, N.Y., the firm,* 1942. 140 *pages.*

621.88. MEANS OF ATTACHMENT; FASTENINGS

Reynolds Metals Company, *Louisville, Ky.* **"Mechanical Fastening Methods for Aluminium."** *Louisville, the Company,* 1951. 136 *pages. Illustrated. Diagrams.*

621.9. MACHINE TOOLS; MACHINING

Aluminium Company of America, *Pittsburgh, Pa.* **"Machining Alcoa Aluminium."** *Pittsburgh, the Company,* 1950. 67 *pages. Illustrated. Diagrams.*

Cincinnati Milling Machine Company, *Cincinnati, Ohio.* **"Hydraulic Control and Feeding Mechanisms for Machine Tools."** *Cincinnati, the Company,* 1942. 36 *pages. Illustrated. Diagrams.*

Dow Chemical Company, *Midland, Michigan.* **"Machining Magnesium."** *Midland, the Company,* 1951. 64 *pages. Illustrated. Diagrams.*

PAPERS RECEIVED

1845: "Plastics and Die Casting" by L. N. Jones.

1883: "The Design, Manufacture and Use of 5″ Sliding, Surfacing and Screw Cutting Lathes" by D. H. Turnbull.

1884: "The Design of Wrapping and Card Box Making Machinery" by J. W. Smith.

1885: "Diesel Engine Progress" by Arthur J. Lund.

1886: "Some Problems of the Indian Engineering Industry" by F. Foster.

The Library Members are asked to note that the Library will be open between 10 a.m. and 5.30 p.m. from Monday to Friday each week.

Journal Binders Members are reminded that binding cases for the Journal are obtainable from Head Office, price 7/6 each post free. The cases, each of which will hold 12 issues of the Journal, are made of stiff board covered with imitation leather cloth, with gilt lettering on the spine.

Research Publications A number of copies of the following Research publications are still available to members, at the prices stated :

Report on Surface Finish, by Dr. G. Schlesinger	15/6
Machine Tool Research & Development	10/6
Practical Drilling Tests	21/-
Test Charts for Machine Tools, Parts 3 and 4	5/6 each

These publications may be obtained from the Production Engineering Research Association, "Staveley Lodge" Melton Mowbray, Leics.

Issue of Journal Owing to the fact that output has to be adjusted to meet requirements, and in order to avoid carrying heavy stocks, it has been decided that the Journal will only be issued to new Members from the date they join the Institution.

Important In order that the Journal may be despatched on time, it is essential that copy should reach the Head Office of the Institution not later than 40 days prior to the date of issue, which is the first of each month.

VITREOUS ENAMELLING

by S. HALLSWORTH *

Presented to the Birmingham Section of the Institution, 16th January, 1952

THE origin of enamelling began before the birth of Christ, although this was actually the " art " of enamelling and was practised on jewellery. It is quite likely that the Egyptians were the first to make enamels, but it is improbable that they got beyond the threshold of enamelling on rare metals.

The art of enamelling began to take definite form in the early part of the Christian era. The goldsmith was responsible for one method in which fine gold wire was soldered so as to form a border around designs he wished to enamel. The areas to be enamelled were then filled with the powdered material, either in the dry condition or as a soft paste. This was pressed firmly into position and placed into a furnace where the heat melted the enamel into a smooth surface of glass. The piece of crude enamel was ground until the gold wire appeared as a boundary around each design or different colour of enamel, and the whole was finally polished.

The coppersmith was accustomed to working with a heavier stock and he found it more convenient to carve and gouge out rather than build up his metal. The enamel itself was applied in a similar manner to the one used by the goldsmith.

Early in the sixteenth century marks the era when the art became the enamelling industry. This era was the beginning of the practice of applying enamel in the form of paint and then fusing it on to the metal. Poor adherence and covering power were among the difficulties met with in this practice, but these enamels mark the transition period between the art of enamelled jewellery and the development of the industry, which is of wide importance in applying the " eye-appeal " to an already accepted base metal.

Enamels passed through the stages in which they were applied on gold only, then on silver, bronze and copper. The application to iron was the most important one and the first record of enamelling on iron was in the eighteenth century. The greatest advances, however, have taken place since the beginning of the twentieth century, and enamelling practice has progressed so rapidly during the past twenty-five to thirty years that it is now a large and progressive industry.

This progress has no doubt been due to the influence of the chemist and the Production Engineer. Prior to the late twenties,

* *Director, Metal Porcelains Ltd. Chairman of Council, Institute of Vitreous Enamellers.*

vitreous enamelling was a mixture of secret formulae and closed shops; the introduction of the chemist, the formation of technical institutes giving a more open approach, widened the knowledge of vitreous enamels, and so enabled this progress to be made.

A further trend has been for companies to purchase their frit* from manufacturers who specialise in this work. The frit manufacturing companies spend much of their time on research and development work, and thus enable the enamellers to concentrate on the application side of the process.

Composition

Vitreous enamels may be briefly but aptly described as " glass fused on metal," and differ from synthetic or baked-on enamels by being entirely inorganic. Consisting of glass fused on metal at 750 to 850°C., they will withstand much higher temperatures without burning off or discolouring. They are more resistant to weathering abrasion and chemical attack.

In considering the properties of vitreous enamel coatings on iron or steel, they must be visualised as thin coatings of low melting glasses of special composition applied to the metal by fusion.

On cast iron, the enamel glass adheres by physical adhesion to the rough surface. On sheet iron or steel, which have comparatively smooth surfaces, the attachment of glass to metal is due to chemical bond. Although recent developments have included white enamels which can be applied direct to the metal, it is necessary to use a special type of steel such as titanium alloy steel which has only been produced in very limited quantities, together with special methods of processing, and the conventional method of applying the white enamel over a blue-black ground coat is still used for normal production.

It is always a source of wonder to the uninitiated that a dark coloured, almost black, ground coat is used to produce a white enamelled sheet. One of the chief essentials of a sheet iron ground coat enamel is to give the proper adherence of the enamel to the metal which, as previously stated, is due to a chemical bond between the glass and the metal. Quite a number of theories have been advanced to explain this bond. One, that cobalt silicate is formed with the evolution of oxygen and this reaction cleaned the iron and made intimate contact possible. Another, that the metallic oxides are reduced to their metals which alloy with the iron, and the enamel

* A glassy material produced by fusing a mixture of some or all of the constituents of a glaze or enamel to render insoluble any soluble material present, and to ensure greater homogeneity, to lower the melting point and to render toxic compounds non-poisonous. In fritting, the raw materials are melted to a molten glass, which is then run from the furnace into a tank of cold water which fractures the glass so that it can easily be ground in the mill.

adheres tenaciously to this alloy. Third, that the metallic dentrites* form a layer between the enamel and the iron projecting into the enamel layer and thus aiding adherence. Whatever the chemistry of the phenomenon, oxidation of the metal is necessary, and the presence of cobalt and other metallic oxides are essential to promote satisfactory adherence.

Regardless of the type, both ground coat and cover coat enamels must be so compounded that they " fit " the metal base, that is, the coefficient of expansion of the glass from the temperature of solidification to the ultimate temperature must be such that, when cool, no undue strains are set up in the glass coating because of compression or tension.

The raw materials used in the manufacture of vitreous enamel frit may be roughly divided into three main classifications—i.e. refractories, fluxes and opacifiers. To these are added at a later stage the colouring oxides, flocculating agents and electrolytes.

The refractories include such materials as silica, felspar and clay which contribute to the acidic part of the melt and give body to the glass.

The fluxes include Borax, Sodium Carbonate, Potassium or Sodium Nitrate, Barium Carbonate, Zinc Oxide, etc., which are basic in character and react with the acidic refractories to form the glass. Materials with a dual role such as Cryolite, Fluorspar and Sodium Silico Fluoride serve as fluxes and secondary or accessory opacifiers.

The major opacifiers include Antimony Oxide, Zirconium Oxide, Titanium Oxide and Tin Oxide, which are mainly refractory in character.

The composition of an enamel varies considerably according to the metal to which it is applied and to the finish required, and is further complicated by the number of elements which it contains. It is formed by the fusion of a number of raw materials and the reaction of the various elements during the fusion process. The analysis does not, in itself, give all the information necessary to produce a satisfactory enamel. It can be likened to a cross-word puzzle in which the analysis gives the clues and the elements in the various raw materials are the alternatives. For instance, the silica can be obtained from Quartz Sand, Felspar and Sodium Silico Fluoride; the Alumina from Felspar, China Clay and Cryolite; Boric Oxides from Borax or Boric Acid; Calcium Oxide from Limestone, Calcium Carbonate and Fluorspar;

* R. M. King believes that the adherence is related to the formation of metallic dentrites which, from X-ray investigations, appear to be alpha iron. These dentrites form a layer between the enamel and the iron, sometimes projecting quite far into the enamel layer. In this manner they aid the adherence.

Fluorine from Cryolite, Fluorspar and Sodium Silico Fluoride; Potassium Oxide from Potassium Carbonate, Potassium Nitrate and Felspar, and so on. It is, at the same time, rather interesting to note that the elements exhibiting the same " functions " in an enamel occupy neighbouring positions in the periodic classification, which does help the chemist in the compounding of enamel formulae. Cobalt and nickel, which give to sheet iron ground coat its adherence to the iron, occur together with iron in the periodic table. Potassium and sodium, which are almost interchangeable, in some enamels occur together. Aluminium occurs between the base and silica, the same position as it holds in enamels. Magnesium, calcium and barium occur in the same group near sodium and potassium, and they react similarly in an enamel. Tin, antimony and zirconium are closely associated in the table and in enamels they are again grouped together as opacifiers.

Enamel Manufacture

The enamel, as received by the enamel works, is in the form of frit which is really a fused mixture of raw materials quenched in water. There are several reasons for fritting, one of which is that some of the chief ingredients are soluble in water, and if a mixture of various raw materials were ground with water and applied as an enamel, the soluble salts would rise to the surface of the enamel during drying, thereby reducing the fusibility of the remainder of the enamel and spoiling the fused surface. Further, some of the most important constituents of an enamel lose a considerable proportion of their weight in the form of volatile gases when being converted into an enamel, and if this expulsion of gases occurred during the brief period in which an enamel is fused on to the metal, time would not permit of the interaction between the materials and would not proceed far enough to produce a glass free from gas bubbles.

Weighing and Mixing of Raw Materials

The raw materials comprising the batch are carefully weighed out and thoroughly mixed. Modern mixers are large cylinders similar to concrete mixers, hexagonal cylinders or horizontal mixers. The horizontal type are generally trough shape, containing a revolving shaft on which are mounted paddles or spirals to mix the materials.

The complete mixing of the batch is very important, since the batch is made up of refractories and fluxes, the speed of reaction during smelting is dependent on a uniform mixture. Since the rate of reaction is directly proportionable to the surface contact, the more intimate the mixing the more surfaces exist between the particles of the flux and refractories.

Smelting Smelting involves the melting together of the raw materials entering the enamel composition until a fairly uniform glass is formed, the temperature required being 1050 to 1250°C.

The physical and chemical changes taking place in the smelting of enamels are quite complicated. The fundamental changes are, however, the interaction of the acids and bases, decompositions, fusion and solution. The exact nature and order of these changes depend upon several conditions, such as temperature, the combination of the raw materials, and the agitation.

Jewellery enamels and enamels for copper and bronze are usually made in small batches and smelted in covered crucibles.

Where large quantity production is required, specially designed smelting furnaces are used. There are several types of smelters in use but the two most popular ones are the tank and rotary types.

The Tank Furnace This type of furnace is of simple construction and consists essentially of a refractory box or tank with the bottom sloping to a point on one side, or in the centre, wherever the tapping hole is situated. They can be fired by coal, oil or gas, the flames and flue gases pass over the enamel batch and are radiated from the crown of the furnace. The batch is charged through a hole in the crown of the furnace and is levelled out by means of a rake or rod through a port hole in the side.

Rotary Furnace The rotary type consists of a steel cylinder bolted on to cast iron end plates machined on the flanges which ride on four flanged wheels, these being rotated by an electric motor. The drum is lined with high grade firebrick. This type of furnace is oil or gas fired and can be revolved at various stages during the process.

When the various reactions are complete, the molten enamel is run off into quenching tanks containing cold water. The principle object of quenching is to facilitate grinding. If the molten glass was cooled slowly, hard lumps would be formed which would be difficult to crush or grind, but by falling into cold water the molten glass is shattered into small pieces which grind comparatively easily.

Preparation of Enamel for Application to Metal There are two Application Processes—Dry Process and Wet Process. The dry process is used for large cast iron vessels, such as, baths, certain sanitary ware, and certain copper and rare metals. Application to sheet iron and to the normal castings used in the manufacture of domestic appliances is by the wet process.

Enamelling Milling

Wet process enamel, usually designated enamel slip or slurry, is the powdered frit suspended in water by means of flocculating agents together with any colouring oxides required.

The enamel slurry is prepared by grinding in a ball mill usually lined with porcelain blocks, and using porcelain balls or flint pebbles as grinding media. For dry process enamelling this is very simple, the frit being simply ground to the required fineness for sieving on to the casting to be enamelled. It is, however, more intricate in the wet process method as finely divided frit is not totally colloidal, hence the necessity for flocculating agents.

Physical and Chemical Considerations of an Enamel Slurry

An enamel slurry is a complex system consisting of a suspension of several solid phases in one liquid. The solid phases vary in particle size from minute grains to 40 mesh material, and include constituents such as frit, clay, opacifiers and colouring agents. The liquid phase is usually a water solution containing electrolytes in the form of soluble salts, acids or alkalies. The composition and properties of the solution affect the peptization, or the flocculation or deflocculation, of the colloidal solids, which, in turn, affect the suspension of all the solid phases present. In other words, the suspension of powdered glass in water is made possible by the soluble salts from the enamel, together with the various materials added during the milling operation. These also control the viscosity of the enamel slurry, thus rendering it suitable for application by normal technique and enabling variations to be made to suit various application methods. The variables in different enamels necessitate different methods of obtaining satisfactory suspension.

Clay is the most important addition in an enamel slurry to give suspension. It is also a necessary addition to give the dried slurry an adherence to the ware and a hardness which permits handling. The electrolytes have more of a chemical action which, either alone or in combination with clay, bring about the suspension of the enamel frit. Some of these electrolytes, such as the salts of magnesium, calcium and barium, tend to form gelatinous compounds, which assist by means of their physical characteristics. Other salts, such as borax, form a buffer solution, which, by this means, controls the alkalinity of the solution, and thus influences the suspension because of its power of keeping the hydrogen ion concentration the same.

The frit is weighed and charged into the mill, followed by the clay and other materials. The enamel is ground to definite standards including fineness, specific gravity and mobility.

Cleaning of Sheet Iron before Enamelling

It is essential that components for enamelling shall be free from grease, scale, oxide, etc. The lubricant used during fabrication can be removed by grease burning, trichlorethylene degreasing or alkali cleaning.

Grease burning is usually carried out in the enamelling furnaces and, although it is very suitable for holloware with beaded rims, it is rather costly and in addition results in the formation of oxide which has to be subsequently removed in the pickling process; therefore, the trichlorethylene or alkali cleaner is more popular in most enamelling plants.

Trichlorethylene Degreasers

There are two main types of degreasing plants —(1) vapour only, (2) vapour and liquid. The vapour type consists of a tank of suitable size containing a sump at the bottom and a coil containing running water at the top. The sump is filled with trichlorethylene and its temperature raised to boiling (87°C.) when a clear vapour is given off. The warm vapour condenses on the cold metal surface, dissolves the grease and falls back into the sump.

Chemical Cleaner

Consists of a tank, usually made of steel, of the capacity required for the size and volume of the work to be processed. The cleaning compound consists mainly of sodium carbonate, sodium hydroxide, sodium phosphate and resin.

Pickling

Both hydrochloric and sulphuric acids are used in the pickling operation. A 6% solution of sulphuric acid at a temperature of 140 to 150°F., or a 10% solution of hydrochloric acid at room temperature are the usual concentrations.

Cleaning of Cast Iron

Cast iron receives different treatment in its preparation for enamelling than sheet iron. Cast iron does not pickle satisfactorily and practically all castings are shot blasted before enamelling.

In the majority of plants the castings are annealed before blasting. This serves a two-fold purpose in that it removes any oil from machining operations and also renders the castings more suitable for enamelling.

Cast iron contains occluded gases which are given off by heat and once driven off are not reabsorbed. Annealing will, therefore, remove these gases and it also has a stabilising affect on the structure of the cast iron.

Blasting is an operation in which abrasive grains are thrown against the ware. This may be done by using compressed air or

revolving paddles. The abrasive, which is usually chilled metallic grit, is thrown with great force which removes the scale and roughens the surface making it suitable for enamelling.

Application of Enamel

Before proceeding with the actual application it is important that the correct type of enamel is used. Jewellery, copper, cast iron, sheet steel and aluminium invariably require different enamels and, to a variable extent, different methods of processing. I do not propose to deal with the enamelling of aluminium because, although I know that considerable development work has been carried out on this metal and that samples have been prepared in the laboratory, I am not personally aware of any large scale production work being done. At the same time, a special enamel is required and the methods of processing are in some respects different from that of iron and steel.

(As the enamelling of iron and steel is by far the most important part of the industry, I propose to restrict my discussion of methods of application to these two metals.)

The usual method of applying wet process enamels is by dipping, swilling or spraying.

Dipping

Sheet iron ground coat enamels are usually applied by either dipping or swilling unless the size or shape of the article makes this impracticable.

In the dipping operation the metal is immersed in the enamel slurry, withdrawn, and allowed to drain. Complicated shapes have to be " rolled " through the enamel to ensure an even coating. Care is necessary to ensure that the predetermined consistency of the slurry is kept constant as the thickness of the enamel coating will vary accordingly.

Swilling

Holloware, or articles having turned over, rolled or beaded rims cannot be satisfactorily coated by the dipping method. The enamel tends to build up in, or run back from, the rim resulting in an uneven coating and creating trouble in the subsequent processing. This type of article is immersed in, or covered with the slurry and on removal the surplus enamel is shaken off, this being quite a skilled operation.

Spraying

Spraying is the application of enamel slurry to the ware by atomizing it through an air gun, whereby the fine spray impinges on the ware. This method is used when only one side of the article is to be covered. Clear air is essential, and filters are incorporated in the air line.

Drying Drying of vitreous enamels is the comparatively simple process of removing the water which has been previously added to the enamel frit, and the only practical way of carrying out this process is by means of evaporation. Insofar as the actual drying process is concerned, any method of applying heat to the ware can be used and, until recent years, little or no attention was paid to the principles of drying, and any method which promoted the evaporation of the water was considered satisfactory without any attempt to control the temperature or humidity, and with little consideration of the results obtained.

In practice, air movement is necessary to the process of drying and heat is required to accelerate the speed of drying. Heat changes the water from the liquid to the vapour state and the air absorbs and carries the water vapour away. Heat also increases the absorption capacity of the air, for example, an increase in the temperature of air from 52 to 72°F. will double its power of absorbing moisture. At the same time air is quickly saturated with water vapour and it is, therefore, necessary that the air film in contact with the enamel is constantly removed.

It is quite possible to dry sheet iron enamels in the open shop without producing any enamel defects but the process is very slow, and requires a considerable amount of space. If, on the other hand, drying takes place too quickly and without correctly designed driers, case hardening of the enamel takes place which prevents the easy escape of moisture from under the surface which, together with the tension set up as the inner materials contract, causes disruption of the surface layer and results in tearing or crawling during subsequent fusing.

From this it can readily be seen that the speed of drying depends upon the speed of flow of water to the surface of the enamel by capillary action, and successful drying can only be obtained where the water is removed from the surface of the enamel at the same or less speed than the water can rise to the surface. Increases in temperature increase the rate of moisture diffusion through the enamel, and the critical temperature and rate of drying is that which ensures the diffusion of the moisture through the enamel at the same speed as the outer surface loses its moisture.

The thickness of coating and the fineness of grinding also influence the rate of drying. The thicker the coating, the slower the rate of moisture diffusion, and the lower the temperature at which it can be dried and, the finer the enamel, the less readily can the particles accommodate themselves to contraction. The humidity of the air in close proximity to the surface of the enamel has some influence on successful drying, and suitable ventilation or spillage is embodied in the design of the drier.

Physical and Chemical Considerations

The fusing of vitreous enamels involves not only the smelting of the enamel but many accompanying physical and chemical changes. We have discussed the effect of cobalt and its effect on adherence of sheet iron ground coats. To develop good adherence available oxygen is also necessary. This must come from either the atmosphere or some oxide at the surface of the metal. A thin layer of rust is always present on the sheet after drying, and it is interesting to note that this disappears after fusing.

At the commencement of the fusing operation of sheet iron ground coat gases are evolved through the surface of the enamel after which the glass melts down to a smooth layer containing many minute gas bubbles. These gases probably originate from the iron, the enamel, and from reactions taking place at the interface of the enamel and the iron.

An interesting phenomena can be observed during the ground coat fusing. A microscopic film was taken in America of this fusing process, which showed first a microscopic tearing or cracking of the surface of the unmelted enamel. As the temperature increased, the enamel curled or ruffled up the melts with a wavy appearance. This gradually smoothed out and appeared quite clear. Soon afterwards, however, bubbling started and the bubbles rose to the surface and burst. Different sizes of bubbles were evidenced but as the fusing proceeded the large ones were eliminated and a number of nearly uniform size remained.

The fusing of sheet iron cover coat does not involve so many changes as the ground coat. The contact surface between the cover coat and the ground coat must be an interfusion between the enamels.

As with the sheet iron ground coat, all wet process cast iron enamels boil during fusing, but towards the end of the operation the bubbling quietens down and a smooth layer is formed. The gases producing this boiling come mainly from the iron, although a considerable amount may be produced by the reaction of the enamel with the iron.

Fusing

Correct support of the ware in the furnace during fusing is very important and it should be properly supported on, or hung from, heat resisting alloy tools so that it will not warp or deform in the heat. The alloy should be of such a composition that will reduce scaling to a minimum in order to avoid small particles of scale flying on to the ware. They should also be designed so that a low weight ratio is obtained between the tools and the ware in order to get good thermal efficiency.

Control of time and temperature during the fusing process is necessary in the production of uniformly fused high quality enamel ware. Pyrometic equipment is now almost standard on fusing furnaces and, where gas or electricity is used as a fuel, automatic temperature control is usually adopted.

Furnaces Furnaces used in the enamelling industry are of the full muffle type with the products of combustion circulating round the outside of the muffle. This applies to both the static or box furnace and the continuous types.

Coal, oil, producer gas, town's gas and electricity are used as fuel.

All continuous enamelling furnaces can be divided into three zones: the hot zone or fusing chamber; the preheating, and the cooling sections.

In one type of furnace the ware is carried on specially designed racks or perritts on activated rollers. The other type of furnace embodies a split crown. The furnace chain passes over the roof of the furnace and the hooks and rods, which hold the carriers which, in turn, support the ware, pass through the space between the two sections of the crown. Whilst the latter can be straight through or horseshoe, the roller type is always a straight through furnace.

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RATING AMPS.	LIST NOS.	A S T A CERTIFICATE NUMBERS		
		B.S.88: 1939	B.S.88: 1947	
		440 AC 4	440 AC 4	440 AC 5
30	T1A30	617	1016	2074
60	T1S60	616	903	2022
100	TC100	615	932	2021
200	TF200	251	933	2033
300	TKF300	252	934	2032
400	TM400	629	935	2031
500	TT500	354	936	2025
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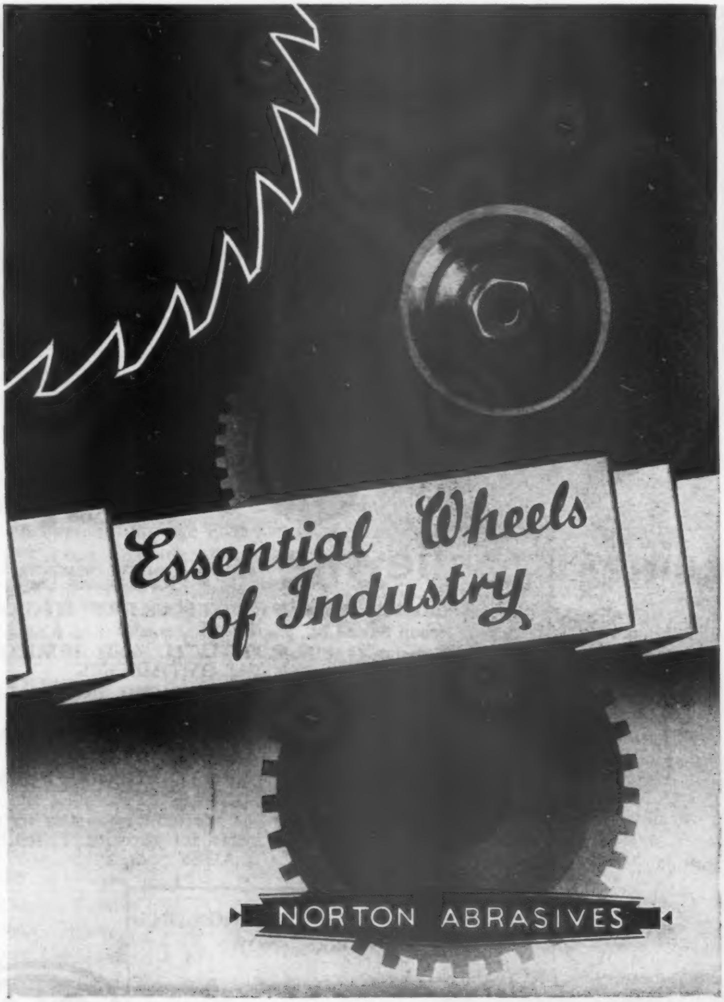

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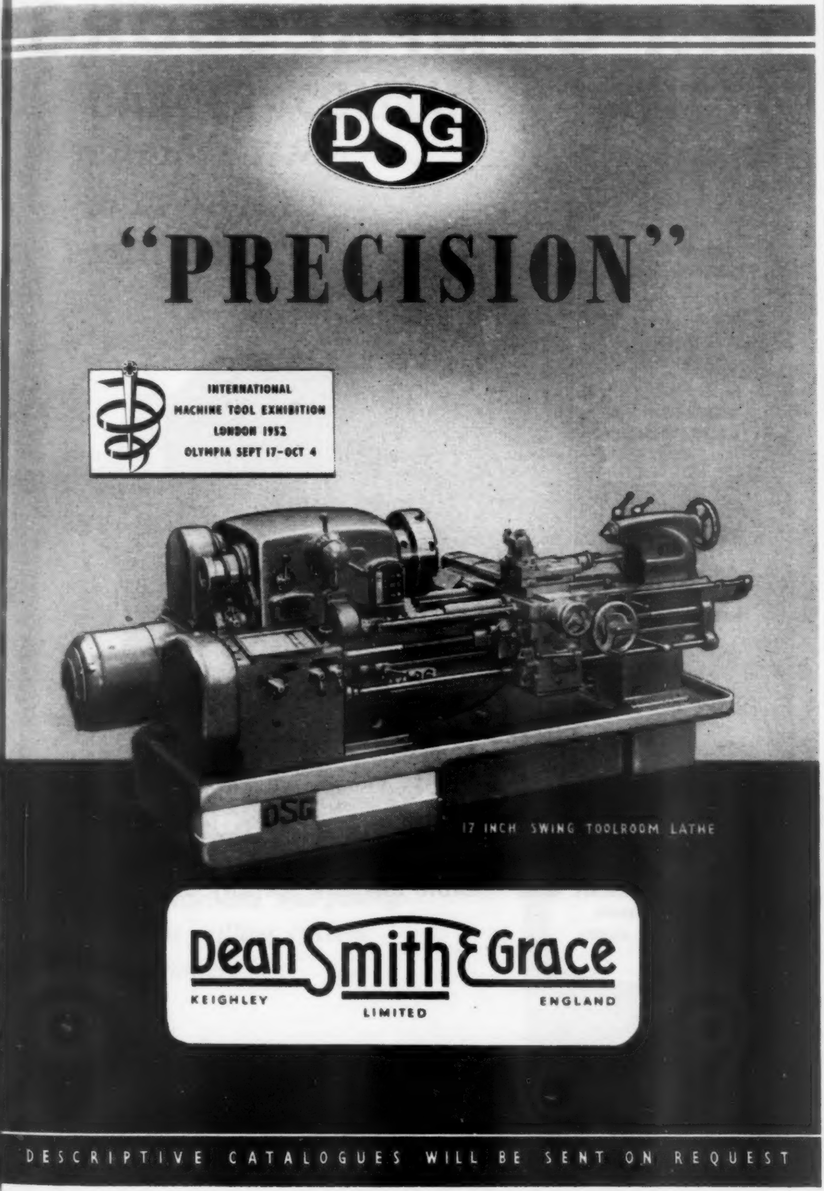
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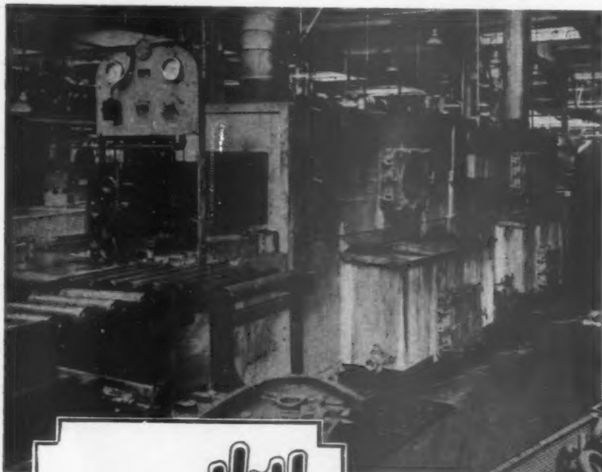

Bratby

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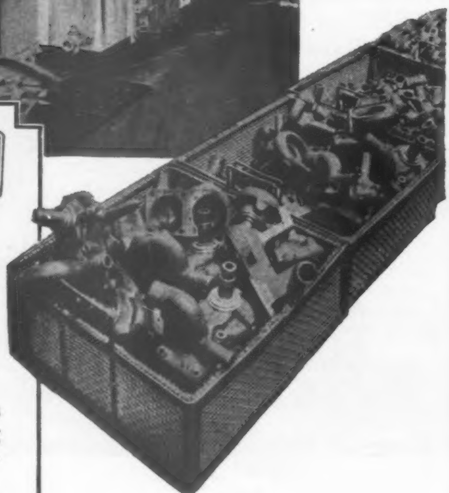

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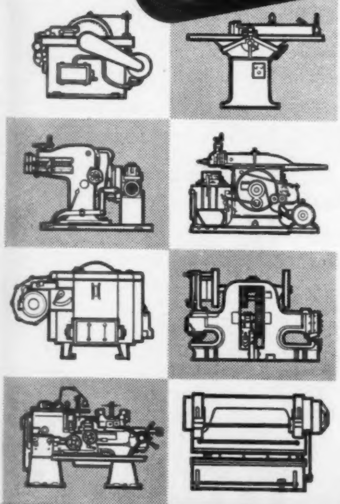

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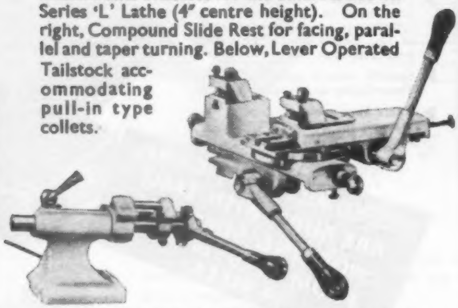

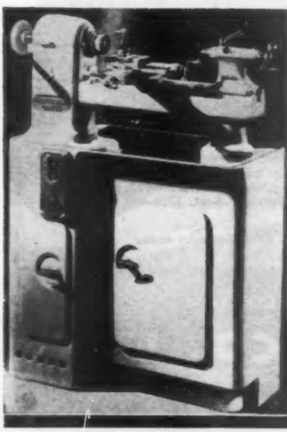

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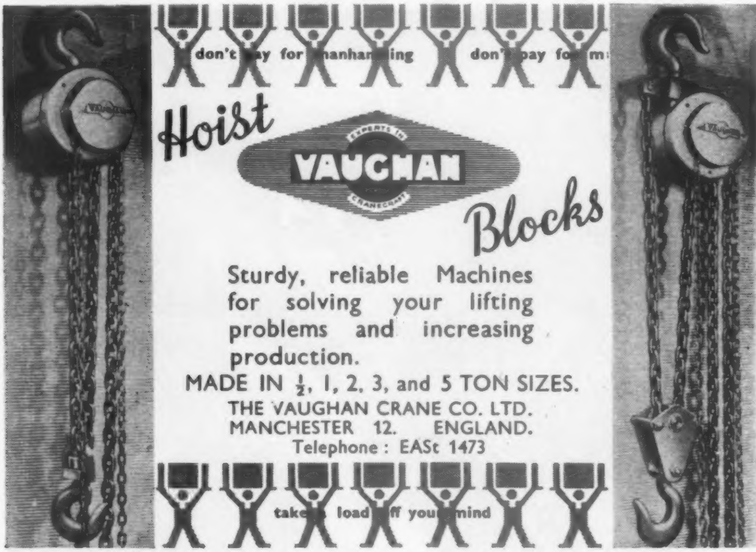
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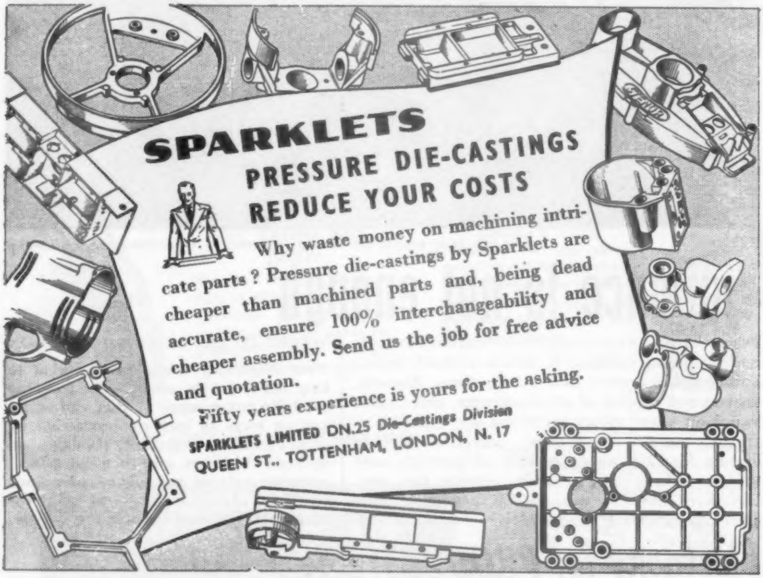
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